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November 4, 1968

A DESCRIPTION OF THE OUTPUT
AND DISPLAYS OF THE APOLLO
MISSION PLANNING AND REAL-TIME
RENDEZVOUS SUPPORT PROGRAM

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SUPPORT PROGRAM

By Jerome W. Kahanek, OMAB

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DECEMBER 13, 1968

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Page 1 of 11.

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PROJECT APOLLO

A DESCRIPTION OF THE OUTPUT AND DISPLAYS
OF THE APOLLO MISSION PLANNING AND
REAL-TIME RENDEZVOUS SUPPORT PROGRAM

By Jerome W. Kahanek
Orbital Mission Analysis Branch

November 4, 1968

MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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A DESCRIPTION OF THE OUTPUT AND DISPLAYS OF THE
APOLLO MISSION PLANNING AND REAL-TIME RENDEZVOUS SUPPORT PROGRAM

By Jerome W. Kahanek

SUMMARY AND INTRODUCTION

This report describes the output and displays of the Apollo Mission Planning and Real-Time Rendezvous Support Program (ARRS, or "The Monster") developed by the Orbital Mission Analysis Branch. The ARRS, as the name implies, was designed as a rendezvous mission support program in the Real-Time Auxiliary Computing Facility (RTACF) and also as a mission planning program.

Most of the output is in the form of displays which are similar to the displays in the Real-Time Computer Complex (RTCC) program. The displays vary from the RTCC displays in that no Greek symbols can be used and the displays are static while the RTCC has dynamic displays.

The displays output in the program are as follows:

1. General purpose maneuver display (GPMP): This display shows impulsive quantities for any one of 48 GPMP maneuvers.
2. Two-impulse multiple solution display: This display is output for any two-impulse solution but the primary purpose is to evaluate multiple two-impulse solutions.
3. Two-impulse single solution display: This display is output for each solution in the multiple solution display. It provides more details on each maneuver and provides backup quantities associated with terminal phase maneuvers.
4. Two-impulse digitals display: This display is only output on NCC-NSR two-impulse solutions. This display provides quantities necessary for evaluating a two-impulse solution to adjust conditions at NSR.
5. Two-impulse best solution display: This display is only output on NCC-NSR two-impulse solutions. If Δh at NSR was varied it will show the best ΔV solution for each Δh .

6. Two-impulse plot: This display is only output on NCC-NSR two-impulse solutions. It shows transfer time and ΔV for each Δh solution.

7. Best NCC-NSR solution display: This display shows the best NCC-NSR ΔV solution from the many solutions computed varying the time of NSR and the Δh at NSR.

8. Rendezvous planning table display (RPT): This display can show up to 17 DKI solutions for different rendezvous M numbers. The mission plan selected from the RPT has to be recomputed in order to submit it to the MPT.

9. Rendezvous evaluation display: This display gives a more detailed description of a mission plan displayed on the rendezvous plan table or of a mission plan using the CSI-CDH solution.

10. Prelaunch targeting display: This display provides the targeting quantities sent to the launch vehicle.

11. Mission planning table display (MPT): This display shows all of the maneuvers on which a finite burn has been applied.

12. Mission planning table detailed maneuver display: This display gives a detailed description of the finite burn parameters for each maneuver in the mission planning table.

13. Relative print digitals: This display gives the relative motion of two vehicles and includes any maneuver performed on the vehicle if the maneuver is in the MPT.

14. TQ10 ephemeris and relative print display: This display gives the ephemeris of both vehicles in different coordinate systems and other orbital parameters. Also, the relative position of each vehicle to the other is provided. The ephemeris and relative print will include any maneuver performed on the vehicle if the maneuver is in the MPT.

TABLE I.- GENERAL PURPOSE MANEUVER DISPLAY (GPMP)

(a) Sample display format

MAN VEH STA ID CSM	WEIGHT	32623.0
	CODE	CDJ00FCIT
GET A	27 33 20.7	
HA	197.5	
LONG A	2 37 W	
LAT A	12 54 S	
GET P	26 48 27.8	
HP	120.4	
LONG P	170 25 W	
LAT A	13 17 N	
A	3602.2	
E	0.01058501	H MAN
I	31.611	LONG MAN
NODE AN	168 37 E	LAT MAN
DEL G	58 15 W	
		161.0
		107 21 E
		29 16 S
		3

TABLE I.- GENERAL PURPOSE MANEUVER DISPLAY (GPMP) - Continued

(b) Definition of symbols

<u>Display quantity</u>	<u>Definition</u>
MAN VEH STA ID	call letters of station used for last trajectory update for the maneuvering vehicle
WEIGHT	weight of vehicle at time of maneuver, lb
CODE	maneuver code
GETAV	ground elapsed time of anchor vector for last trajectory update, hr:min:sec
GETTH	ground elapsed time at which processor is to begin searching for next maneuver point, hr:min:sec
GET A	ground elapsed time of arrival at the resultant apogee, hr:min:sec
HA	height of apogee (above spherical earth) resulting from the maneuver, n. mi.
LONG A	longitude of apogee resulting from the maneuver, deg
LAT A	geocentric latitude of apogee resulting from the maneuver, deg
GET P	ground elapsed time of arrival at the resultant perigee, hr:min:sec
HP	height of perigee (above spherical earth) resulting from the maneuver, hp
LONG P	longitude of perigee resulting from the maneuver, deg

TABLE I.- GENERAL PURPOSE MANEUVER DISPLAY (GPMP) - Concluded

(b) Definition of symbols - Concluded

<u>Display quantity</u>	<u>Definition</u>
LAT P	geocentric latitude of perigee resulting from the maneuver, deg
A	semimajor axis of the orbit resulting from the maneuver, n. mi.
E	eccentricity of the orbit resulting from the maneuver
I	inclination of the orbit resulting from the maneuver, deg
NODE AN	longitude of the first ascending node resulting from the maneuver, deg
DEL G	shift in line of apsides, deg
GETI	ground elapsed time of impulse time for maneuver execution, hr:min:sec
DEL V MAN	velocity increment required to perform the maneuver, fps
DEL TB MAN	burn duration time, min:sec
PIT MAN	pitch attitude of vehicle with respect to local horizontal, deg
YAW MAN	yaw attitude of vehicle with respect to local vertical, deg
H MAN	height (above spherical earth) of vehicle at impulsive time for maneuver execution, n. mi.
LONG MAN	longitude of vehicle at impulsive time for maneuver execution, deg
LAT MAN	geocentric latitude of vehicle at impulsive time for maneuver execution, deg

TABLE III.- TWO-IMPULSE MULTIPLE SOLUTION DISPLAY

(a) Sample display format

LM STA ID	IVB	CSM STA ID	CSM
LM GETTHS	28 1 0.	CSM GETTHS	28 1 0.
MAN VEH	CSM	PHASE	0.
WT	140.900	DEL H	0.
GET1	28 58 6.6	OPTION	FIRST FIXED
GMT1	43 58 6.6		7 MIN UNTIL DARKNESS
DEL V1	YAW	DEL V2	YAW
19.26	3.43	27.33	29 33 26.1
	PITCH	GET2	PITCH
	27.33	21.45	6.79 -39.94
			N 1

TABLE II.- TWO-IMPULSE MULTIPLE SOLUTION DISPLAY - Continued

(b) Definition of symbols

<u>Display quantity</u>	<u>Definition</u>
LM STA ID	standard seven-character ID code indicating the LM anchor vector radar station at the time the display quantities were generated, the type of radar, and the revolution in which the data were gathered
CSM STA ID	same as above except for CSM
LM GETTHS	time tag of the vector from the current ephemeris table to be used in computing the maneuver, hr:min:sec
CSM GETTHS	same as above except for CSM
MAN VEH	maneuvering vehicle
PHASE	desired phase angle at the second maneuver, deg
WT	central angle of travel between the first and second maneuver, deg
DEL H	desired differential altitude at the second maneuver, n. mi.
GET1	ground elapsed time of the first maneuver, hr:min:sec
OPTION	ID indicating whether the first, second, or both maneuver times are fixed
GMT1	Greenwich mean time of the first maneuver, hr:min:sec
DAY/NIGHT INFO	time until daylight or darkness for the fixed time maneuver, min
DEL V1	impulsive ΔV for the first maneuver, fps

TABLE II.- TWO-IMPULSE MULTIPLE SOLUTION DISPLAY - Concluded

(b) Definition of symbols - Concluded

<u>Display quantity</u>	<u>Definition</u>
YAW	yaw angle of the first maneuver, deg
PITCH	pitch angle above local horizontal of the first maneuver, deg
GET2	ground elapsed time of the second maneuver, hr:min:sec
DEL V2	impulsive ΔV for the second maneuver, fps
YAW	yaw angle of the second maneuver, deg
PITCH	pitch angle above local horizontal of the second maneuver, deg
L	letter D or N indicating whether the variable time maneuver occurs in daylight or darkness
C	code specifying the row number of the particular solution in the table

TABLE III.- TWO IMPULSE SINGLE SOLUTION DISPLAY

(a) Sample display format

LM STA ID	I VB	CSM	STA ID	CSM
LM GETTHS	28 1 0.	CSM	GETTHS	28 1 0.
MAN VEH		CSM	PHASE	FWD
MODE		DTR	DEL H	0.
ID	1	WT	DEL PITCH	-0.
GET	28 58 6.6	EHOR -15.65	RANGE	X DOT
DV	19.2634	VX 17.083	26.17	-95.9265
YAW	3.4344	VY 1.025	24.29	-94.4670
PITCH	27.3263	VZ -8.843	22.43	-92.6978
	7 MIN UNTIL DARKNESS	PITCH HA 158.335	20.62	-90.5336
				-18.35T
GET	TGT AZ	TGT EL		Z
DV	6.6 -0.26 L	21.39 U		Y
YAW	6.6 -0.33 L	23.12 U		
PITCH	6.6 -0.41 L	25.12 U		
	28 58 6.6 -0.49 L	27.45 U		
	7 MIN UNTIL DAYLIGHT			
GET	29 33 26.1	EHOR -16.64	RANGE	X DOT
DV	21.4495	VX 16.331	1.31	-23.5502
YAW	6.7852	VY 1.943	0.86	-22.1263
PITCH	-39.9381	VZ 13.770	4.511	0.43
	7 MIN UNTIL DAYLIGHT	PITCH HA 161.618	4.370	-21.5479
				0.00
GET	TGT AZ	TGT EL		Z
DV	26.1 -168.07 L	65.74 U		Y
YAW	26.1 -170.83 L	56.66 U		
PITCH	26.1 -172.41 L	47.99 U		
	29 33 26.1 124.99 R	44.51 U		

TABLE III.- TWO-IMPULSE SINGLE SOLUTION DISPLAY - Continued

(b) Definition of symbols

<u>Display quantity</u>	<u>Definition</u>
LM STA ID	standard seven-character ID code indicating the LM anchor vector radar station at the time the display quantities were generated, the type radar, and the revolution in which the data were gathered
CSM STA ID	same as above except for CSM
LM GETTHS	ground elapsed time tag of the vector from the LM ephemeris table to be used in computing the maneuvers, hr:min:sec
CSM GETTHS	same as above except for CSM
MAN VEH	vehicle performing the maneuver
PHASE	desired phase lag at the second maneuver time, deg
MODE	ID (either TGI or LOS) indicating the body-referenced coordinate system selected via input for the (XD, YD, ZD) ΔV definition defined below
DTR	time between the two maneuvers, hr:min:sec
DEL H	desired differential altitude at the second maneuver time, n. mi.
ID	code identifying the row number of the corresponding solution in the two-impulse multiple solution table or the two-impulse digital display
WT	central angle of travel of the target vehicle between maneuvers, deg

TABLE III.- TWO-IMPULSE SINGLE SOLUTION DISPLAY - Continued

(b) Definition of symbols - Continued

<u>Display quantity</u>	<u>Definition</u>
DEL PITCH	angle between the astronaut's line of sight (LOS) and the X-axis of the spacecraft (+ represents a counterclockwise rotation about the Y_b axis)
GET	ground elapsed time of the impulsive maneuver time, hr:min:sec
EHOR	angle between the astronaut's LOS to the horizon and the local horizontal plane, deg
GMT	Greenwich mean time of the impulsive maneuver time, hr:min:sec
DV	impulsive incremental velocity required by the maneuver, fps
YAW (on left of display)	yaw attitude relative to the local vertical/local horizontal (LVLH) reference frame at main engine ignition required to place the thrust vector along the ΔV vector (+ to the right), deg
PITCH (on left of display)	pitch attitude relative to the LVLH reference frame at main engine ignition required to place the thrust vector along the ΔV vector (+ up), deg
VX, VY, VZ	components of the incremental velocity along the X-, Y-, Z-axis, respectively, of either the target-defined or horizontal-defined body axis systems discussed in [table III(c)], fps

TABLE III.- TWO-IMPULSE SINGLE SOLUTION DISPLAY - Continued

(b) Definition of symbols - Continued

<u>Display quantity</u>	<u>Definition</u>
YAW (in center of display)	yaw angle between the X-axis of the spacecraft and the local horizontal plane whenever the astronaut's LOS is to the target or the horizon, deg
PITCH (in center of display)	pitch angle between X-axis of space- craft and local horizontal plane whenever astronaut's LOS is to the target or horizon, deg
XD, YD, ZD	components of the incremental velocity along the X-, Y-, and Z-axis, respectively, of either the target-defined or horizontal-defined body axis systems discussed in [table III(c)], fps
DT (associated with XD)	burn time required to impart the velocity increment XD along the X-axis of the body axis system, defined in [table III(c)], by firing the fore or aft firing RCS thrusters, min:sec
DT (associated with YD)	burn time required to impart the velocity increment YD along the Y-axis of the body axis system by firing left or right firing RCS thrusters, min:sec
DT (associated with ZD)	burn time required to impart the velocity increment ZD along the Z-axis of the body axis system by firing the up or down firing RCS thrusters, min:sec
DAY/NIGHT INFO	time until daylight or darkness for the fixed time maneuver, min
HA	apogee height after the maneuver, n. mi.

TABLE III.- TWO-IMPULSE SINGLE SOLUTION DISPLAY - Concluded

(b) Definition of symbols - Concluded

	<u>Display quantity</u>	<u>Definition</u>
HP		perigee height after the maneuver, n. mi.
GET		ground elapsed time corresponding to the particular row of the approach data displayed, hr:min:sec
TGT AZ		azimuth of the target vehicle in the chaser vehicle's local vertical/ local horizontal coordinate system, deg
RANGE		range from the chaser to the target, n. mi.
R DOT		range rate between chaser and the target, fps
X, Y, Z		position coordinates of the chaser vehicle in a target-centered curvilinear coordinate system, n. mi. The letters L or T, R or L, and U or D are to be printed out with the position coordinates X, Y, and Z, respectively, to indicate whether the target vehicle is leading or trailing, to the right or to the left of, and above or below, the chaser vehicle.

TABLE III.- TWO-IMPULSE SINGLE SOLUTION DISPLAY

(c) Coordinate definitions

1. The LHLV coordinate axes are as follows:

- a. $+\bar{X}$ in the orbit plane perpendicular to the position vector \bar{R}_P and in the direction of motion
- b. $+\bar{Y}$ along $\bar{X} \times \bar{R}_P$
- c. $+\bar{Z}$ along $\bar{X} \times \bar{Y}$ (+ down)

2. The target-defined body coordinate axes are as follows:

- a. $+\bar{X}$ along the spacecraft X_b -axis whenever the vehicle is in a "wings level" orientation with the astronaut's LOS aligned to the target vehicle
- b. $+\bar{Y}$ along the cooresponding Y_b -axis
- c. $+\bar{Z}$ along the corresponding Z_b -axis

3. The horizon-defined body coordinate axes are as follows:

- a. $+\bar{X}$ along the spacecraft X_b -axis whenever the vehicle is in a "wings level" orientation with the astronaut's LOS aligned to the horizon
- b. $+\bar{Y}$ along the corresponding Y_b -axis
- c. $+\bar{Z}$ along the corresponding Z_b -axis

TABLE IV TWO-IMPULSE DIGITALS DISPLAY

(a) Sample dispersion front at

INITIAL	G.	E.	TIME	FINAL	INITIAL YDOT	XDOT	YDOT	ZDOT	INITIAL YDOT	XDOT	YDOT	ZDOT	FINAL YDOT	INITIAL YDOT	XDOT	YDOT	ZDOT	TSLIP
26 25 0.	27	59	0.	10000.00	10000.00	0.	10000.00	10000.00	0.	10000.00	10000.00	0.	284.279765	0.	0.	0.	0.	
26 25 0.	27	59	15.0	58.52	256.73	1.64	-94.37	-224.04	-0.50	506.427734	9.00	1.50	0.					
26 25 0.	27	59	30.0	58.72	243.05	1.58	-94.57	-207.44	-0.45	478.026897	9.00	1.49	0.					
26 25 0.	27	59	45.0	58.90	231.10	1.53	-94.75	-192.57	-0.41	453.107647	9.00	1.49	0.					
26 25 0.	28	0	0.	59.05	220.60	1.48	-94.91	-179.16	-0.37	431.112717	9.00	1.48	0.					
26 25 0.	28	0	45.0	59.42	195.74	1.36	-95.30	-145.51	-0.28	378.498425	9.00	1.47	0.					
26 25 0.	28	1	0.	59.52	189.18	1.33	-95.41	-135.99	-0.26	364.446362	9.00	1.47	0.					
26 25 0.	28	1	15.0	59.62	183.31	1.29	-95.51	-127.14	-0.24	351.783703	9.00	1.47	0.					
26 25 0.	28	1	30.0	59.71	178.36	1.49	-95.62	-118.87	-0.42	340.369514	9.00	1.46	0.					
26 25 0.	28	1	45.0	59.79	173.32	1.43	-95.71	-111.11	-0.38	329.997238	9.00	1.46	0.					
26 25 0.	28	2	0.	59.87	169.74	1.38	-95.80	-103.83	-0.35	320.611763	9.00	1.46	0.					
26 25 0.	28	2	15.0	59.95	165.19	1.34	-95.89	-96.98	-0.32	312.111763	9.00	1.45	0.					
26 25 0.	28	2	30.0	60.02	161.71	1.30	-95.97	-90.47	-0.29	304.389908	9.00	1.45	0.					
26 25 0.	28	2	45.0	60.09	158.58	1.26	-96.02	-84.27	-0.27	297.367149	9.00	1.44	0.					

TABLE IV.- TWO-IMPULSE DIGITALS DISPLAY

(b) Definition of symbols

<u>Display quantity</u>	<u>Definition</u>
G.E. TIME: Initial Final	ground elapsed time of the initial and the final maneuver, hr:min:sec
INITIAL XDOT YDOT ZDOT	Velocity components of the initial maneuver, fps
FINAL XDOT YDOT ZDOT	velocity components of the final maneuver, fps
TOTAL DELTA V	sum of the ΔV 's for the first and second maneuvers plus an approxi- mation of the terminal phase ΔV , fps
DH	differential altitude at the time of the second maneuver (positive if the active vehicle is to be below the passive vehicle at NSR), n. mi.
DP	phase angle at the time of the second maneuver (always positive - measured from the active vehicle to the passive vehicle in the direction of motion), deg
TSLIP	amount of time terminal phase initia- tion will differ from nominal if the corresponding two-impulse solu- tion is used, min

TABLE V.—TWO-IMPULSE BEST SOLUTION DISPLAY

(a) Sample display format

TIME OF FIRST MANEUVER	GET	26 25 3.	GMT	149100.00	SECONDS
SECOND MANEUVER				TSLIP	
SEL	H M S	F/S	DELTA V	DELTA H	DEG MIN
154965.00	28 2 45.0		237.312	7.000	1.123C53
154965.00	28 2 45.0		267.136	8.000	1.283489
154965.00	28 2 45.0		297.357	9.000	1.443925

TABLE V.- TWO-IMPULSE BEST SOLUTION DISPLAY - Concluded

(b) Definition of symbols

<u>Display quantity</u>	<u>Definition</u>
GET	ground elapsed time of the first (NCC) maneuver, hr:min:sec
GMT	Greenwich mean time of the first (NCC) maneuver, sec
	The following quantities are output for the second maneuver of each different Δh solution.
GMT	Greenwich mean time of the seoond (NSR) maneuver, sec
GET	ground elapsed time of the second (NSR) maneuver, hr:min:sec
DELTA V	ΔV of the second maneuver, fps
DELTA H	differential altitude at the NSR maneuver point, n. mi.
DELTA THETA	phase angle at the NSR maneuver point, deg
TSLIP	amount of time terminal phase initiation will differ from nominal if the corresponding two-impulse solution is used, min

TABLE VI.— TWO-IMPULSE PLOT DISPLAY

(a) Sample display format

DELTA V TOTAL ---F/S		DELTA V TOTAL ---V	
237.31	249.32	261.33	273.35
*****	*****	*****	*****
N.M.	*	*	*
7.00	*	3	
8.00	*	1	
9.00	*	1	
			V
97.75	97.75	97.75	97.75
*****	*****	*****	*****
			V
			97.75

TABLE VI.- TWO-IMPULSE PLOT DISPLAY - Concluded

(b) Definition of symbols

<u>Display quantity</u>	<u>Definition</u>
DELTA H	differential altitude, n. mi.
DELTA V TOTAL	total ΔV , fps
DELTA V TRANSFER	transfer time, min

The transfer time for each DELTA H is plotted as the letter T. The DELTA V for each DELTA H is plotted as the letter V. If both points occur at the same spot a letter B is printed out on the plot.

TABLE VII.- BEST NCC-NSR SOLUTION DISPLAY

(a) Sample display format

THE BEST JELTA V FOUND WAS		237.312	FINAL	FOR A HEIGHT OF	7.00 NM	AND A PHASE ANGLE OF	1.1231 DEGREES
INITIAL	TIME =	149100.00		TIME =	154965.00		
XDOT =		51.746		XDOT =	-81.40		
YDOT =		123.514		YDOT =	-66.10		
ZDOT =		1.048		ZDOT =	-0.29		

TABLE VII.-- BEST NCC-NSR SOLUTION DISPLAY - Concluded

(b) Definition of symbols

Display quantity	Definition
INITIAL TIME	time of the NCC maneuver, sec
XDOT	components of the incremental velocity along the X-, Y-, and Z-axis, respectively, of the LVLH reference frame at the impulsive maneuver point, fps
YDOT	
ZDOT	
FINAL TIME	time of the NSR maneuver, sec
XDOT	components of the incremental velocity along the X-, Y-, Z-axis, respectively, of the LVLH reference frame at the impulsive maneuver point, fps
YDOT	
ZDOT	

TABLE VIII.- RENDEZVOUS PLANNING TABLE DISPLAY (RPT)

(a) Sample display format

| CSM STA ID CSM DKI |
|--------------------|--------------------|--------------------|--------------------|
| GMTLO | GMTLO | GMTLO | GMTLO |
| 0 17 0 0. | 0 17 0 0. | 0 17 0 0. | 0 17 0 0. |
| ID M DV CSM DV LM |
15 15 1494.3 0.	21 23 11.0 0.	GETDKI	GETDKI
14 14 1494.1 0.	19 54 36.4 0.	NPC	NPC
		NH	NH
		1.25	1.25
		1.25	1.25
		1.5	1.5
		2.0	2.0
		2.0	2.0
		13.0	13.0
		14.0	14.0
		14.0	14.0
		25.1	25.1
		25.1	25.1
		59.4	59.4
		59.4	59.4
		WT	WT
		140.00	140.00
		1334.14	1334.14

TABLE VIII.- RENDEZVOUS PLANNING TABLE DISPLAY (RPT) - Continued

(b) Definition of symbols

<u>Display quantity</u>	<u>Definition</u>
CSM STA ID	identification code for the CSM anchor vector used in the processing
LM STA ID	identification code for the CSM anchor vector used in the processing
GMTLO	Greenwich meantime of lift-off, day:hr:min:sec
GMTLOR	Greenwich meantime of recommended lift-off time, day:hr:min:sec
TL	GMTLO minus GMTLO* where GMTLO* is the LM lift-off time such that phase match would result at first apogee, min:sec
WT	the input control angle through which the target vehicle will travel during terminal phase, deg
DVPC	total ΔV required for the plane-change maneuver, fps

The following quantities are output for each DKI plan submitted to the rendezvous plan table.

ID	row number of a particular rendezvous mission plan
M	orbit number in which rendezvous is to occur
DV CSM	total ΔV required from the CSM for a particular mission plan, fps
DV LM	total ΔV required from the LM for a particular mission plan, fps
GETDKI	elapsed time from CSM lift-off at which the target arrives at the rendezvous point, hr:min:sec

TABLE VIII.- RENDEZVOUS PLANNING TABLE DISPLAY (RPT) - Concluded

(b) Definition of symbols - Concluded

<u>Display quantity</u>	<u>Definition</u>
NPC	maneuver line crossing at which the plane-change maneuver will be made
NH	maneuver line crossing at which the height maneuver will be made for mode 1 plans
NCL	maneuver line crossing at which the phase rate adjustment maneuvers will be made for mode 1 plans
NCH1	maneuver line crossing at which the phase rate adjustment maneuver will be made for mode 2 plans
NCH2	maneuver line crossing at which the height adjustment maneuver will be made for mode 2 plans
NSR	maneuver line crossing at which the coelliptic maneuver will be made
DTL	amount by which the currently input GMTLO can be delayed and still permit rendezvous in the same orbit number using the same rendezvous mode, min:sec

TABLE IX.- RENDEZVOUS EVALUATION DISPLAY

(a) Sample display format					
ID	6	6	6	6	6
GET	DT	DV	VEH	PURP	CODE
3 20 0.	1340	-18.85	CSM	C1	1.00
25 40 7.3			CSM	SR	16.00
TARGET AT SR	142.071	HP		118.531	
HA					
PITCH	YAW	VX	VY	VZ	
0.004	180.000	-18.85	0.00	-0.00	
24.370	-0.004	9.61	-0.00	-4.35	
REQUIRED PHASE AND HEIGHT AT SR					
PHASE -1.2000 HEIGHT -0.2000					

TABLE IX.- RENDEZVOUS EVALUATION DISPLAY - Continued

(b) Definition of symbols

<u>Display quantity</u>	<u>Definition</u>
ID	row number of a particular rendezvous mission plan
M	orbit number in which rendezvous is to occur
GET	impulsive time of the maneuver, hr:min:sec
DT	amount of time between one maneuver in the table and the next maneuver in the table to be performed by the same vehicle, hr:min
DV	impulsive ΔV for the maneuver, fps
VEH	vehicle (CSM or LM) used to perform the maneuver
PURP	ID indicating the purpose of the particular maneuver within the solution
CODE	number of the maneuver line at which the maneuver is to occur. Blanked if the plan is a concentric flight plan
PHASE	phase angle between the two vehicles following the maneuver (always positive - measured from the chaser vehicle to the target vehicle in the direction of motion), deg
HEIGHT	differential altitude between chaser and target vehicles following the maneuver (positive if the chaser vehicle is below the target vehicle), n. mi.

TABLE IX.- RENDEZVOUS EVALUATION DISPLAY - Concluded

(b) Definition of symbols - Concluded

<u>Display quantity</u>	<u>Definition</u>
HA	apogee altitude above the Cape radius of the maneuvering vehicle trajectory resulting from the maneuver, n. mi.
HP	perigee altitude above the Cape radius of the maneuvering vehicle trajectory resulting from the maneuver, n. mi.
This display also shows the target apogee and perigee height (above Cape radius) at the coelliptic maneuver point and the desired phase angle and differential altitude at the coelliptic point.	
PITCH	pitch of each maneuver measured in the local vertical, local horizontal coordinate system, deg
YAW	yaw of each maneuver measured in the local vertical, local horizontal coordinate system, deg
VX, VY, VZ	components of the incremental velocity along the X-, Y-, and Z-axis, respectively, of the LVLH reference frame at the impulsive maneuver point, fps

TABLE X.- PRELAUNCH TARGETTING DISPLAY

(a) Sample display format

STA	ID	AAP2	OVS	GETLOR	0	-0	-0.	TGRR	19	11	26.4
GMTLOR	67	11	26.4	GETLIC	0	21	33.6				
GMTLO	67	33	C.		0			VIGM	7841.23		
TW			279.45	AZL			83.037		25725.83		
H			81.00	AZL	83	2	14	VCO	7835.14		
DH			95.37	XR			4940.96	RIGM	6523358.63		
ML			180.000	AZP			84.165	GIGM	0.00042558		
AN			201.132	YP			0.0524	IIGM	28.932		
								TIGM	101.675		
								TDIGM	-0.0C42600		
											25725.83

TABLE X.- PRELAUNCH TARGETING DISPLAY - Continued

(b) Definition of symbols

<u>Display quantity</u>	<u>Definition</u>
STA ID	tracking vector on which computations are based
GMTLOR	Greenwich mean time of computed recommended lift-off time, hr:min:sec
GETLOR	ground elapsed time of computed recommended lift-off time, hr:min:sec
GMTLO	Greenwich mean time of input lift-off time
GETLO	Ground elapsed time of input lift-off time, hr:min:sec
TGRR	Greenwich mean time of guidance reference release, hr:min:sec
TW	time difference between GMTLOR and GMTLO* where GMTLO* is the lift-off time corresponding to phase match at some input angle around from insertion or at apogee, sec
AZL	launch azimuth in degrees for insertion into target orbit plane; also displayed in deg:min:sec
VIGM	inertial insertion velocity, fps
H	actual insertion altitude, n. mi.
VCO	inertial cutoff velocity, fps
DH	actual differential altitude, n. mi.
XR	launch vehicle roll gimbal angle error, corresponding to the flight azimuth for insertion into the target orbit plane, deg

TABLE X.- PRELAUNCH TARGETING DISPLAY - Concluded

(b) Definition of symbols - Concluded

<u>Display quantity</u>	<u>Definition</u>
RIGM	insertion radius vector magnitude, ft
ML	angle from insertion to maneuver line or to point at which GMTLO* is measured, deg
AZP	parallel launch azimuth, deg
GIGM	inertial flight-path angle, measured between velocity vector and local horizontal (positive nose up), deg
AN	earth-fixed ascending node of the target vehicle at the time of launch vehicle insertion, deg
YP	magnitude of wedge angle that exists between the insertion plane and target orbit plane for the parallel flight azimuth, deg
IIGM	instantaneous inclination angle, deg
TIGM	nodal parameter measured from launch pad meridian to descending node of the target orbit plane, referenced to guidance reference release, deg
TDIGM	regression rate of the target orbit plane, earth fixed, to include earth rotation, deg/sec

TABLE XI.- MISSION PLANNING TABLE DISPLAY (MPT)

(a) Sample display format

GETDKI -15 -0 -0.						LEM STA ID IVB GETAV 26 18 55.1					
CSM STA ID CSM	26 25 10.0					NC1 -0.0	NCH2 -0.00	NSR -0.00			
GETAV	104592	NPC -0.00				NCH1 -0.0					
	M4592	NH -0.00									
GMT IMP	GETBI	DT	DELTA V	DVREM	HA				HP	CODE	
13 0 19.3	28 0 19.3	1 27	42.5	-185.8	153.55				113.14	CSS01CDH	
14 27 59.4	29 28 1.8	0 34	24.9	18.4	-204.2	153.67			120.72	CRG02TP1	
15 2 56.1	30 2 26.7			17.8	-222.1	161.31			120.89	CRG03TPF	

TABLE XI.- MISSION PLANNING TABLE DISPLAY (MPT) - Continued

(b) Definition of symbols

<u>Display quantity</u>	<u>Definition</u>
CSM STA ID	call letters of station used for last update of CSM trajectory
GETAV	ground elapsed time of anchor vector for CSM update, hr:min:sec
LM STA ID	call letters of station used for last update of LM trajectory
GETAV	ground elapsed time of anchor vector for LM update, hr:min:sec
GETDKI	ground elapsed time at which the target vehicle arrives at the rendezvous plan table (RPT)
ID	the row number of the selected DKI plan in the rendezvous plan table (RPT)
M	the orbit number in which the rendezvous is to occur
NPC	the maneuver line crossing at which the plane change for the rendezvous is to occur
NH	the maneuver line crossing at which the height adjust for mode 1 rendezvous is to occur
NCL	the maneuver line crossing at which the phasing adjust for mode 1 rendezvous is to occur
NCH1	the maneuver line crossing at which the phasing adjust for mode 2 rendezvous is to occur

TABLE XI.- MISSION PLANNING TABLE DISPLAY (MPT) - Concluded

(b) Definition of symbols - Concluded

<u>Display quantity</u>	<u>Definition</u>
NCH2	the maneuver line crossing at which the height adjustment for mode 2 rendezvous is to occur
NSR	the maneuver line crossing at which the coelliptic maneuver is to occur
The following quantities will be displayed for each maneuver in the table.	
GMT IMP	Greenwich mean time of the impulsive maneuver point, hr:min:sec
GETBI	ground elapsed time of the burn initiation, hr:min:sec
DT	time duration between maneuvers, min:sec
DELTA V	incremental velocity required to complete the maneuver, fps
DVREM	delta V remaining after the maneuver, fps
HA	height of apogee above Cape radius after the maneuver, h. mi.
HP	height of perigee above Cape radius after the maneuver, n. mi.
CODE	code assigned to the maneuver in the MPT

TABLE XI.- MISSION PLANNING TABLE DISPLAY (MPT) - Continued

(c) Display quantity CODE

The CODE on the MPT display gives the following information.

1st letter	vehicle performing the maneuver C - CSM L - LM
2nd letter	thruster used on maneuver R - RCS S - SPS D - DPS A - APS
3rd letter	mode in which maneuver was computed S - SCS, inertial G - Lambert, guided M - manual X - external delta V
4th and 5th	number of maneuver in the MPT
Last four letters	maneuver identification. See list of GPMP maneuvers in MSC internal note no. 68-FM-223.
NH	DKI height maneuver, upper mode
NCl	DKI phasing maneuver, upper mode
NCH1	DKI phasing maneuver, lower mode
NCH2	DKI height maneuver, lower mode
NPC	DKI plane-change maneuver
NSR	DKI coelliptic maneuver
CSI	CSI-CDH horizontal phasing maneuver
CDH	CSI-CDH coelliptic maneuver
NCC	two-impulse phasing and height com- bination maneuvers

TABLE XI.- MISSION PLANNING TABLE DISPLAY (MPT) - Concluded

(c) Display quantity CODE - Concluded

NSR	two-impulse NCC-NSR coelliptic maneuver
TPI	two-impulse terminal phase initiation maneuver
TPF	two-impulse terminal phase final maneuver

TABLE XII.—MISSION PLANNING DETAILED MANEUVER DISPLAY

(a) Sample display format

TABLE XII.- MISSION PLANNING DETAILED MANEUVER DISPLAY - Continued

(b) Definition of symbols

<u>Display quantity</u>	<u>Definition</u>
CSM STA ID	CSM tracking vector on which computations are based
LM STA ID	LM tracking vector on which computations are based
CODE	code assigned to the maneuver in the MPT. The first letter is either C or L, meaning CSM or LM. The second letter is the thruster identification, R-RCS, S-SPS, P-PPS, and A-APS. The third letter identifies attitude mode used, S-SCS, G-Guided, M-manual, and X-external ΔV . Next is the maneuver number and the maneuver identification, i.e., NCC, NSR, TPI, etc.
DVC	velocity increment to be imparted along the vehicle X-axis to include ullage but not tailoff, fps
DVM	total velocity increment to be imparted to vehicle to include ullage and tailoff, fps
DTU	duration of the ullage for the maneuver, sec
DTBO	duration of the main engine burn, min:sec
VGX, VGY, VGZ	components of the incremental velocity vector in the IMU coordinate system, fps. For guided maneuvers, the ΔV vector is to be the V_G vector from the guidance equations computed from the state vector at main engine ignition without the effect of ullage. For non-guided maneuvers, the ΔV vector is the total ΔV computed for the maneuver.

TABLE XII.- MISSION PLANNING DETAILED MANEUVER DISPLAY - Continued

(b) Definition of symbols - Continued

<u>Display quantity</u>	<u>Definition</u>
GET1	ground elapsed time of the main engine ignition, hr:min:sec
PI, YM, RO	IMU pitch, yaw, and roll gimbal angles at main engine ignition for the CSM, deg. If the LM is maneuvering the sequence is PI, YO, RM.
VF, VS, VD	components of the ΔV vector in the local vertical local horizontal (LVLH) coordinate system (+VF is in the orbit plane perpendicular to the position vector \bar{R}_p and in the direction of motion; +VS is along $\bar{R}_p \times \bar{V}_p$; and +VD is along $-\bar{R}_p$)
DVTO	total incremental velocity imparted to the vehicle by tailoff, fps
YH, PH, RH	yaw, pitch, and roll attitude angles in the LVLH reference system which define the orientation of the thrust vector at main engine ignition where the thrust vector is aligned along the ΔV vector, deg
DTTO	duration of tailoff, sec
WCI	CSM dry weight plus unusable propellant, lb
WLI	LM dry weight plus unusable propellant, lb
WTI	weight of the vehicle prior to the maneuver, lb

TABLE XII.- MISSION PLANNING DETAILED MANEUVER DISPLAY - Continued

(b) Definition of symbols - Continued

<u>Display quantity</u>	<u>Definition</u>
WMF	weight of the vehicle after doing the maneuver, lb
H BI	height above spherical earth of the vehicle at burn initiation, n. mi.
P BI	geocentric latitude of the vehicle subsatellite point at burn initiation, deg:min (north or south)
L BI	earth-fixed longitude of the vehicle subsatellite of burn initiation, deg:min (east or west)
F BI	true anomaly of the maneuvering vehicle at burn initiation relative to the apsis of the current orbit, deg
GET AN	ground elapsed time of the ascending node of the resulting orbit, hr:min:sec
The following quantities listed under RESULTANT are measured or computed from the vector at burn termination.	
GET HA	ground elapsed time of apogee of the resulting orbit, hr:min:sec
HA	height above the spherical earth of apogee of the resulting orbit, n. mi.
P HA	geocentric latitude of apogee of the resulting orbit, deg:min (north or south)
L HA	earth-fixed longitude of apogee of the resulting orbit, deg:min (east or west)
L AN	earth-fixed longitude of the ascending node of the resulting orbit, deg:min (east or west)

TABLE XII.- MISSION PLANNING DETAILED MANEUVER DISPLAY - Continued

(b) Definition of symbols - Continued

	<u>Display quantity</u>	<u>Definition</u>
GETHP		ground elapsed time of perigee of the resulting orbit, hr:min:sec
HP		height above the spherical earth of perigee of the resulting orbit, n. mi.
P HP		geocentric latitude of perigee of the resulting orbit, deg:min (north or south)
L HP		earth-fixed longitude of perigee of the resulting orbit, deg:min (east or west)
E		eccentricity of the resulting orbit
DH		height differential between the maneuvering and nonmaneuvering vehicle (+ if the maneuvering vehicle is below the other vehicle), n. mi.
P		phase angle between the two vehicles, deg. Always positive measured from the maneuvering vehicle to the nonmaneuvering vehicle in the direction of motion.
DP		phase angle rate, deg/orbit period of the nonmaneuvering vehicle
DEL		wedge angle between the two orbits, deg
I		inclination of the resulting orbit, deg
DAY/NIGHT data		minutes until day or night and the word "DAY" or "NIGHT" indicating whether the maneuver occurs in daylight or darkness

TABLE XII.-- MISSION PLANNING DETAILED MANEUVER DISPLAY - Continued

(b) Definition of symbols - Continued

<u>Display quantity</u>	<u>Definition</u>
DEL P	pitch trim gimbal angle of engine nozzle, deg. Angle at which engine nozzle is pitched from longitudinal axis.
DEL Y	yaw trim gimbal angle of engine nozzle, deg. Angle at which engine is yawed from longitudinal axis.
PGNS	primary guidance and navigation system
AGS	abort guidance system
EXT DV	ID identifying the maneuvering vehicle for the external ΔV displayed
GETI	ground elapsed time of the main engine ignition, hr:min:sec
VX, VY, VZ	components of the external ΔV vector required for targeting the onboard external ΔV guidance for maneuver execution, fps
MVR	ID indicating whether the maneuver is the table is the CSI, CDH, or TPI maneuver of the concentric flight plan
APSIS	number of apsis crossings between the proposed CSI and CDH maneuver which is an uplink parameter to the onboard computer program that computes the onboard concentric flight plan
ELEV	desired or actual elevation angle (up or down) from the chaser to the target vehicle at TPI of the current concentric flight plan, deg

TABLE XII.- MISSION PLANNING DETAILED MANEUVER DISPLAY - Concluded

(b) Definition of symbols - Concluded

	<u>Display quantity</u>	<u>Definition</u>
TPI		desired ground elapsed time of the TPI maneuver of the current concentric flight plan, hr:min:sec
DT		transfer time between TPI and intercept of the current concentric flight plan, min:sec
OPTION		code (ELEV or TIME) indicating whether the concentric flight plan is targeted for an elevation angle or a time at TPI

(c) Maneuver modes

The following is a definition of the four maneuver modes used in the detailed maneuver table.

1. SCS inertial mode:

This mode uses no steering. The thrust vector is in a constant inertial direction throughout the burn. The burn cutoff is determined by a burn time which is computed in subroutine START using an input thrust model and impulsive elements before and after the maneuver. This mode does not use the short burn logic.

2. Guided mode:

The thrust direction in this mode is determined from the Lambert solution. This direction is updated every 2 seconds. However, when the time remaining to burn is less than 4 seconds the thrust direction is held inertially fixed. If CINP is input as 0.0 the thrust is along the ΔV vector. If CINP is input #0.0 the thrust direction is slightly off the ΔV vector to compensate for gravity effects.

The logic burns out the ΔV vector, unless it is a "short burn" in which case the logic burns out a Δt computed from the short burn logic. The thrust model in short burn logic may not be the same as the input thrust model; however, it is supposed to be the same as the onboard thrust model.

TABLE XII.- MISSION PLANNING DETAILED MANEUVER DISPLAY - Concluded

(c) Maneuver modes - Concluded

3. Manual mode:

This mode is identical to an SCS mode except that the body attitude is held inertially fixed and the thrust vector will rotate to follow the center of gravity.

4. External ΔV mode:

This mode is identical to the guided mode except that the thrust direction is held inertially fixed as in the SCS inertial mode, and the ΔV is computed from impulsive elements instead of from the Lambert solution. It uses short burn logic for short burns.

(d) Targets

The following is a discussion of the targets on the detailed maneuver table.

If the CSM performs the maneuver only the PNGS external ΔV is output, the AGS external ΔV is zero.

If the LM performs the maneuver the PNGS and AGS external ΔV is output.

If the maneuver is performed in the guided mode the PNGS external ΔV is zero for either vehicle doing the maneuver.

The resultant orbit quantities on the detailed maneuver are computed on the vector at the time of burn termination.

TABLE XIII.— RELATIVE MOTION DIGITALS DISPLAY

(a) Sample display format

THE CSM IS THE ACTIVE VEHICLE
 POSITIVE X IS IN DIRECTION OF MOTION
 POSITIVE Z IS BELOW
 POSITIVE Y IS TO THE RIGHT
 X, Z, Y ARE IN THE INACTIVE VEH PLANE
 THE REMAINDER ARE IN THE ACTIVE VEH PLANE

GMT	GET			RANGE			CURVILINEAR			REL			
	H	M	S	D	H	M	S	X	Z(DH)	Y	PB	YB	RB
2 19 21 25.2	0	0	9 58.8	1574.5	-1417.0	-1610.9	130.8	4.8	-0.2	-8.0	11.8	49.3	233.1
2 19 22 25.2	c	c	0 10 58.8	1560.5	-1412.7	-1596.3	130.6	4.5	-0.2	-7.8	31.4	237.1	117.3
2 19 23 25.2	c	c	0 11 58.8	1546.6	-1407.1	-1581.6	130.3	4.5	-0.2	-7.7	15.7	252.4	230.1
2 19 24 25.2	c	c	0 12 58.8	1532.7	-1400.5	-1567.1	129.9	5.0	-0.2	-7.5	24.3	241.1	115.4
2 19 25 25.2	c	c	0 13 58.8	1518.9	-1392.7	-1552.6	129.5	5.0	-0.2	-7.4	20.7	243.0	114.7
2 19 26 25.2	c	c	0 14 58.8	1505.2	-1383.8	-1538.2	128.9	5.0	-0.2	-7.3	38.6	62.9	210.7
2 19 27 25.2	c	c	0 15 58.8	1491.6	-1373.9	-1523.9	128.3	5.0	-0.2	-7.1	46.6	64.7	203.4
2 19 28 25.2	c	c	0 16 58.8	1478.1	-1363.1	-1509.7	127.6	4.5	-0.2	-7.0	55.7	66.1	113.4
2 19 29 25.2	c	c	0 17 58.8	1464.7	-1351.2	-1495.6	126.8	4.5	-0.2	-6.9	65.5	66.8	186.2
2 19 30 25.2	c	c	0 18 58.8	1451.4	-1338.5	-1481.7	125.9	4.8	-0.1	-6.7	75.7	66.9	176.8
2 19 31 25.2	c	c	0 19 58.8	1438.3	-1325.0	-1467.8	125.0	4.7	-0.1	-6.6	85.7	66.3	167.7
2 19 32 25.2	c	c	0 20 58.8	1425.2	-1310.8	-1454.2	124.0	4.5	-0.1	-6.5	95.1	65.2	159.1
2 19 33 25.2	c	c	0 21 58.8	1412.4	-1295.8	-1440.6	123.0	4.4	-0.1	-6.4	103.5	63.5	151.6
2 19 34 25.2	c	c	0 22 58.8	1399.7	-1280.3	-1427.3	121.9	4.2	-0.1	-6.3	110.9	61.4	145.0
2 19 35 25.2	c	c	0 23 58.8	1387.1	-1264.2	-1414.1	120.7	4.0	-0.1	-6.2	117.2	58.9	139.5
2 19 36 25.2	c	c	0 24 58.8	1374.7	-1247.7	-1401.0	119.6	3.8	-0.1	-6.1	122.7	56.2	134.9
2 19 37 25.2	c	c	0 25 58.8	1362.5	-1230.8	-1388.2	118.3	3.5	-0.1	-6.0	127.4	53.2	131.1
2 19 38 25.2	c	c	0 26 58.8	1350.4	-1213.6	-1375.5	117.1	3.2	-0.1	-5.9	131.5	50.1	127.9
2 19 39 25.2	c	c	0 27 58.8	1338.5	-1196.2	-1363.0	115.9	3.0	-0.1	-5.8	135.1	46.9	125.2
2 19 40 25.2	c	c	0 28 58.8	1326.8	-1178.7	-1350.7	114.6	2.7	-0.1	-5.7	138.3	43.6	122.9
2 19 41 25.2	c	c	0 29 58.8	1315.2	-1161.1	-1338.6	113.3	2.4	-0.0	-5.6	141.1	40.2	121.0
2 19 42 25.2	c	c	0 30 58.8	1303.8	-1143.6	-1326.7	112.1	2.1	-0.0	-5.6	143.7	36.7	119.4
2 19 43 25.2	c	c	0 31 58.8	1292.6	-1126.3	-1315.0	110.8	1.8	-0.0	-5.5	146.0	33.2	118.1
2 19 44 25.2	c	c	0 32 58.8	1281.6	-1109.2	-1303.4	109.6	1.4	0.0	-5.4	148.2	29.6	117.0

TABLE XIII.-- RELATIVE MOTION DIGITALS DISPLAY - Concluded

(b) Definition of symbols

Display quantity	Definition
GMT	Greenwich mean time, day:hr:min:sec
GET	ground elapsed time, day:hr:min:sec
RANGE	range between the vehicles, n. mi.
RANGE RATE	range rate between the vehicles, fps
X, Y, Z (DH)	position coordinates of the chaser vehicle in a target-centered curvilinear coordinate system, n. mi. X is positive in the direction of motion, Y is positive to the right and Z (DH) is positive below
REL AZI	azimuth of the target vehicle in the chaser vehicle's local vertical, local horizontal (LVLH) coordinate system, deg
REL ELV	elevation angle of the target vehicle in the chaser vehicle's LVLH coordinate system, deg
PB, YB, RB	IMU pitch, yaw, and roll gimbal angles which exist if the specified axis of the chaser is pointed at the target, deg
	The values directly below PB, YB, RB are the FDAI (flight director attitude indicator) pitch, yaw, and roll attitude angles which will exist if the specified axis of the chaser is pointed at the target.

TABLE XIV - TQ10 EPHemeris and RELATIVE PRINT DISPLAY

(a) Sample display format

	DAY	HR	MIN	SEC	HRS	MINUTES	SECONDS
GMT	4	13	5	25.00	109	6545	392725.00
GET FROM VEH 1	3	21	5	25.00	93	5585	335125.00
GET FROM VEH 2	3	21	5	25.00	93	5585	335125.00
VEHICLE NUMBER 1							
1	VI	25482.731445	FPI	0.00358385	AZV	111.671379	1 R
2	X	-126.29624.125	Y	-14854.150.750	Z	9508193.250	2 XOUT
3	A	21707524.500	E	0.0070088		15368.992554	3 YOUT
4	ARGL	127.134882	TA	5.1132313	PERD	122.002568	4 ASNU
5	AN	0.6725601E-01	GN	C.1265557E-03	ALTS	128.773226	5 APOG
6	RDOT	1.596618	DLAT	26.148630	ALTE	128.398521	6 EFND
						256.598560	7 THDO
						0.4038432E 01	8
VEHICLE NUMBER 2							
7	VI	25482.718262	FPI	0.00371547	AZV	111.671379	7 R
8	X	-123.29656.500	Y	-14854.169.750	Z	9508214.625	8 XOUT
9	A	21707584.150	E	0.0070193		15368.940918	9 YOUT
10	ARGL	127.134860	TA	5.304482	PERD	121.8030378	10 ASNU
11	AN	0.6725573E-01	GN	0.126544E-03	ALTS	128.780016	11 APOG
12	RDOT	1.652485	DLAT	26.148640	ALTE	128.405310	12 EFND
						256.598545	13 THDO
						0.4038432E 01	14
RELATIVE POSITION OF VEHICLE 2 MEASURED IN VEHICLE 1 COORDINATE SYSTEM --							
13	RAN	0.007109	RRAT	0.071988	RX	-0.002113	13 RY
14	RAZ	175.294903	REL	72.611552	RX	-0.002113	14 CY
15	WEGD	-0.000025	PABV	0.009891	PDIS	-0.616320	15 PHDM
16	YTV2	1.404671	PTV1	107.333366	RSAZ	-0.000174	15 PHD2
17	RSSI	0.084421	RVD	-0.062975	RUD	-31.40548	16 RSEL
18	RSSR	0.072373	RXO	-0.014651	RYD	0.056117	17 RWD
						-0.003458	18 RZU
						-0.003458	19 TSAN
RELATIVE POSITION OF VEHICLE 1 MEASURED IN VEHICLE 2 COORDINATE SYSTEM --							
19	RAN	0.007109	RRAT	0.071988	RX	0.002113	19 RY
20	KAZ	-5.530683	REL	-72.648048	CX	0.016321	20 CY
21	WEGD	-0.000025	PABV	0.009891	PDIS	0.0000205	21 PHUM
22	YTV2	-1.647140	PTV1	-72.724008	RSAZ	31.228644	22 RSEL
23	RSS1	0.084696	RVD	0.061240	RUD	-0.055493	23 RWD
24	RSSR	0.072373	RXD	0.012746	RYD	0.002963	24 RZU
						-0.002963	25 PDE
						-23.72.597839	26 TSAN

TABLE XIV.- TQ10 EPHemeris AND RELATIVE PRINT DISPLAY - Continued
 (b) Definition of symbols

Variables on lines 1 and 7

VI	inertial velocity, fps
FPVI	inertial flight-path angle, deg. Angle between the inertial velocity vector and the local geocentric horizontal, positive upward.
AZVI	inertial azimuth measured from north of the inertial velocity vector projected on a plane normal to the radius vector, deg
R	radius from center of earth, ft
LONG	earth-fixed longitude of vehicle position, deg (positive east)
ELAT	geocentric latitude of vehicle position, deg (positive north)

Variables on lines 2 and 8

X	components of vehicle position in earth-centered, right-handed inertial coordinate system, ft.
Y	
Z	System is orientated at $T = 0$ with X-Z plane through zero longitude and X-Y plane containing the equator. The Z-axis passes through the north pole.
XDOT	velocity components in the above inertial coordinate system, fps
YDOT	
ZDOT	

Variables on lines 3 and 9

A	semimajor axis, ft
E	eccentricity
I	inclination of orbit to equatorial plane, deg

TABLE XIV.- TQ10 EPHemeris AND RELATIVE PRINT DISPLAY - Continued

(b) Definition of symbols - Continued

ARGP	argument of perigee, positive counterclockwise (as viewed from the north pole) from the ascending node, deg
ASND	longitude of the ascending node (positive counterclockwise from the inertial axis), deg
MA	mean anomaly, deg

Variables on lines 4 and 10

ARGL	argument of latitude, deg
TA	true anomaly, deg
PERD	anomalistic period of vehicle, min
ALTS	altitude above spheroid having radius of Cape, n. mi.
APOS	apogee height above spheroid having radius of Cape, n. mi.
PERG	perigee height above spheroid having radius of Cape, n. mi.

Variables on lines 5 and 11

AN	anomalistic mean motion, deg/sec
GN	secular rate of advance of argument of perigee, deg/sec
HN	secular rate of regression of node, deg/sec
ALTE	altitude above geodetic earth, along radius, n. mi.
EFND	longitude of earth-fixed node (positive east), deg
THDO	rate of change of true anomaly, deg/min

TABLE XIV.- TQ10 EPHEMERIS AND RELATIVE PRINT DISPLAY - Continued

(b) Definition of symbols - Continued

Variables on lines 6 and 12

RDOT	rate of change of the radius vector, fps
DLAT	geodetic latitude of vehicle position, deg
ILON	inertial longitude of vehicle position, deg

Variables on lines 13 and 19

RAN	range, n. mi.
RRAT	range rate, fps
RX	relative rectilinear in-plane distance from each respective vehicle-centered X, Y, Z coordinate system (positive in direction of motion), n. mi.
RY	relative rectilinear radial distance from each respective vehicle-centered X, Y, Z coordinate system (positive radially up), n. mi.
RZ	relative rectilinear out-of-plane distance (positive in direction needed to make up a right-handed system), n. mi.
PHAL	instantaneous value of the phase angle between respective vehicles (positive clockwise), deg

Variables on lines 14 and 20

RAZ	relative azimuth (yaw angle) measured in respective vehicle X-Z plane (positive right), deg
REL	relative pitch angle from respective vehicle (positive up), deg
CX	relative cylindrical in-plane arc distance (positive in direction of motion), n. mi.

TABLE XIV.- TQL0 EPHEMERIS AND RELATIVE PRINT DISPLAY - Continued

(b) Definition of symbols - Continued

CY	relative cylindrical in-plane radial difference (positive radially up), n. mi.
CZ	relative cylindrical out-of-plane distance, n. mi.
WEG	angle between two orbital planes, wedge angle, deg

Variables on lines 15 and 21

WEGD	rate of change of the wedge angle, deg/min
PABV	included angle between two vehicle radii, deg
PDIS	perpendicular distance from respective vehicle to orbit plane of the other vehicle, n. mi.
PHDM	phase angle rate, deg/min
PHD2	phase angle rate, deg/orbit
PHA2	phase angle between the vehicles, corrected for the wedge angle between the orbital planes, deg

Variables on lines 16 and 22

YTV2	relative yaw angle measured after computation of pitch angle (positive right), deg
PTV1	relative pitch angle measured in respective vehicle X-Y plane (positive up), deg
RSAZ	relative azimuth angle between line of sight and sun, deg
RSEL	relative elevation angle between line of sight and sun, deg
ILOS	inertial line of sight for terminal phase, deg

TABLE XIV.- TQ10 EPHemeris AND RELATIVE PRINT DISPLAY - Concluded

(b) Definition of symbols - Concluded

ILSD	rate of change of inertial line of sight, deg/min
<u>Variables on lines 17 and 23</u>	
RSSI	relative rotating inertial velocity, fps
RVD	relative rotating horizontal velocity (positive in direction of motion), fps
RUD	relative rotating radial velocity (positive out along radius vector), fps
RWD	relative rotating out-of-plane velocity (positive direction needed to make up right-handed system), fps
RFPI	relative flight-path angle between respective vehicles, deg
RAZI	relative azimuth between respective vehicles, deg
<u>Variables on lines 18 and 24</u>	
RSSR	relative velocity (positive in direction of motion), fps
RXD	X component in the same system as RX in lines 13 and 17, fps
RYD	Y component in the same system as RY in lines 13 and 19, fps
RZD	Z component in the same system as RZ in lines 12 and 19, fps
PDE	relative azimuth between respective vehicles, deg
TSAN	angle between the line of sight and the sun, deg

TABLE XV.— NEW MISSION PLANNING DETAILED MANEUVER DISPLAY

(a) Sample display format

FOU DETAILED MANEUVER TABLE

C STA	I U	C2	GMPT	L STA	ID	CSM	C	C STA	ID	C2	GMPT	WT	50352.00
GMTV	101 27	54.2	GMTV	15 46	42.4	GMTV	0	0	0	0	0	WC	0.0
GETV	76 29	60.0	GETV	-9-11-11	8	GETV	-24-57-54.2	2	-24-57-54.2	WT	0.0	WL	0.0
CODE			REF	LUNAR		GETR	-24-57-54.2	2	-24-57-54.2	WF	0.0		
GETI	76 34	41.5	DT	3	1 51.3	DT	10	48	REFSMHAI	DEL P	-0.9		
PETI	101 32	35.7	JU	15.00	JU	JU	10	7.02	CASE 2	DEL Y	1.3		
DVM	1604.0	U	VGX	-1118.6	UK	UK	00.5	YB	*J	YH	171.7		
DVRE1	-1104.0	U	VY	959.5	LP	LP	214.1	PB	*0	PH	-74.5		
DVC	1594.1	VZ	VZ	633.1	MY	MY	37.8	RB	0.0	RH	8.1		
VF	-341.17	H	B1	485.0	HA	HA	500.015	VP			5807.75		
VS	-0.00	P	B1	7 4A S	HP	HP	59.892	THETA P			28.03		
VD	1567.29	L	B1	88 44 E	LA	LA	24 12 N	DELTA P			0.00		
DH	0.00	F	B1	-262.43	E	E	*18066490	P LLS	0 0 S				
PHASE	0.00				1	1	171.5553	L LLS	0 0 4				
PHASE DOT	0.00			1 13	NP	NP	69.5581	R LLS	0.000				
WEDGE ANG	*0.00			UNTIL									
YU	*0.000			DARK									
TARGETS													
PONS					AGS								
EXT DV		CSM		EXT DV	CSM								
GETI	76 34	41.5		GETI	76 34	41.5		GETI	76 34	41.5		MVR	76 34 41.5
VX	-291.2761	VX			0.000			T F	-1-50-37.7	A PSIS	0	GETI	
YI	-0.001	YI			0.000			X	-J951784.30	ELEV	*0.00		
VZ	1577.3249	VZ			0.000			Y	-5415952.30	TP1	0 0 0		
								Z	-2610562.80	DT	0 0 0		
								C	0.000	OPTION			

WT AFTER 42927.13

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TABLE XV.- NEW MISSION PLANNING DETAILED MANEUVER DISPLAY

(b) Definition of symbols

<u>Display quantity</u>	<u>Definition</u>
C STA ID	standard identification for CSM vector used in generation of maneuver
GMTV	Greenwich mean time of CSM vector, hr:min:sec
GETV	ground elapsed time of CSM vector, hr:min:sec
CODE	code assigned to the maneuver in the MPT. The first letter is either C or L, meaning CSM or LM. The second letter is the thruster identification, R - RCS, S - SPS, D - DPS, and A - APS. The third letter identifies attitude mode used, S - SCS, G - Guided, M - Manual, and X - external ΔV. Next is the maneuver number in the MPT and then the maneuver identification; i.e., NCC, NSR, TPI, etc.
L STA ID	standard identification for LM (S-IVB) vector used in generation of maneuver
GMTV	Greenwich mean time of LM (S-IVB) vector, hr:min:sec
GETV	ground elapsed time of LM (S-IVB) vector, hr:min:sec
REF	prints out either EARTH or LUNAR depending on the reference body
X STA ID	standard identification for the CSM or LM vector that was used to generate the frozen profile of the maneuver displayed in the DMT
GMTV	Greenwich mean time of frozen maneuver vector, hr:min:sec

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TABLE XV.- NEW MISSION PLANNING DETAILED MANEUVER DISPLAY - Continued

(b) Definition of symbols - Continued

<u>Display quantity</u>	<u>Definition</u>
GETV	ground elapsed time of frozen maneuver vector, hr:min:sec
GETR	reference ground elapsed time for phase elapsed time, hr:min:sec
WT	weight of the total maneuvering prior to the maneuver, lb
WC	CSM dry weight plus unusable propellant, lb
WL	LM dry weight plus unusable propellant, lb
WF	weight prior to the maneuver of the engine performing the maneuver, lb
GETI	ground elapsed time, of ignition, hr:min:sec
PETI	phase elapsed time of ignition, hr:min:sec
DT B	duration of main engine burn, min:sec
DT U	duration of ullage, sec
DT TO	effective duration of main engine tailoff, sec
DV TO	velocity increment of main engine tailoff, fps
REFSMMAT	identification of REFSMMAT used to compute gimbal angles
DEL P	main engine pitch gimbal trim angle from the electronic null position for the SPS or the positive handover position for the DPS, deg

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TABLE XV.- NEW MISSION PLANNING DETAILED MANEUVER DISPLAY - Continued

(b) Definition of symbols - Continued

<u>Display quantity</u>	<u>Definition</u>
DEL Y	main engine yaw gimbal trim angle from the electronic null position for the SPS or the positive handover position for the DPS
DVM	total velocity increment of maneuver, fps
DVREM	total velocity remaining after maneuver, fps
DVC	total velocity increment, less tailoff to be applied along the vehicle X-axis, fps
VGX, VGY, VGZ	prethrust \bar{V}_g output from the guidance equations displayed in IMU coordinates. Computed based on a free-flight vector at GETI, fps
OY, IP, MR	outer, inner, and middle gimbal angles at ignition (0° - 360°). These labels will be dynamic and displayed as follows: for the CSM, roll, pitch, yaw: for the LM, yaw, pitch, roll: for the S-IVB maneuver these will be CSM gimbal angles, deg
YB, PB, RB	FDAI angles. These are the same as the gimbal angles yaw, pitch, roll for CSM maneuvers, but correspond to pilot yaw, pitch, roll for LM maneuvers, deg
YH, PH, RH	local vertical-local horizontal yaw, pitch, and roll at ignition, deg
VF, VS, VD	components of VGX, VGY, VGZ transformed to local vertical coordinates defined at GETI, fps

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TABLE XV.- NEW MISSION PLANNING DETAILED MANEUVER DISPLAY - Continued

(b) Definition of symbols - Continued

<u>Display quantity</u>	<u>Definition</u>
DH	differential altitude at cutoff between LM (S-IVB) and CSM displayed in nautical miles and positive when maneuvering vehicle is below
PHASE	phase angle at cutoff between LM (S-IVB) and CSM measured from chaser to target in the direction of motion (0° - 360°)
PHASE DOT	rate of change of phase angle at cutoff, positive when PHASE is decreasing (degrees per orbit)
WEDGE ANG	wedge angle at cutoff between CSM and LM (S-IVB) orbits, deg
YD	crossrange distance from CSM orbit to LM at insertion following ascent, n. mi. Will be zero for any maneuver other than the ascent maneuver.
H BI	altitude of maneuvering vehicle above spherical earth or moon (defined by REF) at ignition time, n. mi.
P BI	geodetic latitude of maneuvering vehicle at ignition while in earth orbit, deg. Otherwise it is geocentric latitude.
L BI	longitude of maneuvering vehicle at ignition, deg
F BI	true anomaly of maneuvering vehicle at ignition, deg
UNTIL	lighting conditions at GETI, hr:min until day/night

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TABLE XV.- NEW MISSION PLANNING DETAILED MANEUVER DISPLAY - Continued

(b) Definition of symbols - Continued

<u>Display quantity</u>	<u>Definition</u>
HA	altitude of next apoapsis after cutoff above spherical reference, n. mi.
HP	altitude above spherical reference of next periapsis after cutoff, n. mi.
L AN	longitude of next ascending node after cutoff, deg:min
E	orbital eccentricity after cutoff
I	trajectory inclination to (earth or moon defined by REF) resulting from maneuver, deg
WP	argument of perigee or pericynthion (defined REF) resulting from maneuver, deg
VP	velocity at next pericynthion after maneuver for maneuver performed while in lunar orbit, fps
THETA P	central angle between radius vector passing through the next pericynthion after cutoff and the lunar landing site at the time of next pericynthion displayed in degrees and negative when the landing site is beyond pericynthion, deg; driven only for maneuvers while in lunar orbit
DELTA P	wedge angle between orbit at cutoff and a parallel plane passing through the lunar landing site, deg; driven only for maneuver while in lunar orbit
P LLS	latitude of lunar landing site as a result of the powered landing maneuver, deg:min

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TABLE XV.- NEW MISSION PLANNING DETAILED MANEUVER DISPLAY - Continued

(b) Definition of symbols - Continued

<u>Display quantity</u>	<u>Definition</u>
L LLS	longitude of lunar landing site as a result of the powered landing maneuver, deg:min
R LLS	radius of lunar landing site, n. mi.
TARGETS	these quantities are driven according to the type of maneuver displayed. They are as follows:
1. PGNS EXT DV	primary guidance and navigation system ID for vehicle doing the external ΔV maneuver
GETI	ground elapsed time of ignition, hr:min:sec
VX, VY, VZ	components of external ΔV vector required for targeting the onboard PGNCS external ΔV guidance for maneuver execution, fps
2. AGS EXT DV	abort guidance system ID for vehicle doing the external ΔV maneuver
GETI	ground elapsed time of ignition, hr:min:sec
VX, VY, VZ	components of external ΔV vector required for targeting the onboard AGS external ΔV guidance for maneuver execution, fps
3. LAMBERT GETI	ground elapsed time of ignition, hr:min:sec
T F	time of flight from ignition time to the target vector, hr:min:sec
X, Y, Z	inertial target vector, ft
C	cross product steering constant

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TABLE XV.- NEW MISSION PLANNING DETAILED MANEUVER DISPLAY - Concluded

(b) Definition of symbols - Concluded

<u>Display quantity</u>	<u>Definition</u>
4. MVR	ID indicating whether the maneuver in the table is the CSI, CDH, or TPI maneuver of the concentric flight plan
GETI	ground elapsed time of ignition, hr:min:sec
APSIS	number of apsis crossings between the proposed CSI and CDH maneuver which is an uplink parameter to the onboard computer program that computes the onboard concentric flight plan
ELEV	desired or actual elevation angle (up or down) from the chaser to the target vehicle at TPI of the current concentric flight plan, deg
TPI	desired ground elapsed time of the TPI maneuver of the current concentric flight plan, hr:min:sec
DT	transfer time between TPI and intercept of the current concentric flight plan, min:sec
OPTION	code (ELEV or TIME) indicating whether the concentric flight plan is targeted for an elevation angle or a time at TPI

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